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Morphological approaches in colour vision studies

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Colour discrimination in the retina of non-primate mammals is served by two cone types, carrying middle-wave (green, M) and short-wave (blue or ultra-violet, S) sensitive visual pigments, respectively. The two pigments are markedly different from one another, providing a means of immunocytochemical discrimination.

An unexpected topographic separation of M and S cones was found in some rodents. Whereas the dorsal retina is populated by both cone types in the characteristic 10:1 ratio, the ventral retinal half presents an unusual territory in that its exclusive cones are of the short-wave sensitive type. This means that although the global cone density is roughly uniform all over the retina, the two cone types occupy opposite retinal halves. Later, other mammals, among them the rabbit and the guinea pig also proved to be heterogeneous with respect to the distribution pattern of cones. When present, the blue-field always occupies the ventralmost area of the retina. The ventral, short-wave sensitive half continuously scanning the sky for predators might be an advantageous feature. Likewise, the dorsal M-cone-rich retina might be useful for better viewing the green vegetation. Besides, large number of cones express both visual pigments at the same time either within a band or across the entire blue field. The coexistence of two visual pigments within the very same cone cell was also found in other species.

Interestingly, a transitory visual pigment coexpression was also found during the first three weeks of age in rodents. In these animals it is the blue cones that appear first with a dramatic overproduction - as compared to the later expressing green cones. The dominance of the green cones is regained only after the blue pigment is removed from the dual cones. The spatial and temporal coexpression leads to the hypothesis that these elements develop from one another. Transdifferentiation may be the most suitable means to provide for a controllable distribution of the color cones across the retina. There must be a default pathway favouring the differentiation towards the synthesis of the short-wave pigment. The topographical determination of a developmental wave along the dorsal-ventral axis is supported by large numbers of studies that report on the characteristic distribution of proteins in the embryonic eye and dorsal-ventral expression patterns of exogenous opsin genes.

An important question is whether this spatial distribution and temporal sequence can be experimentally modified. Retinal transplants showed relatively normal organotypic maturation, however the paucity of M cones as compared to S cones was a consistent feature. The results of the transplantation experiments indicate that the absence of age-specific environment selectively influences the normal differentiation of M cones, even when the species- and organ-specific factors are available in the host retina.

Omitting the organ-specific environment, similarly to transplants, explanted retinas were completely devoid of M cones. The manipulation coincides with events that are crucial for the differentiation of the green cones. The question addresses recently is the identifications of the factors that modify the spatial and temporal distribution of color cones in mammals.

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